



THE PEAR PSYLLA I N C A L I F O R N I A

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Fifth-instar nymph ("hardshell" stage) of the pear psylla.

This circular . . .

brings you the most recent developments in the battle to control the pear psylla, which now poses a threat to the California pear crop from the Oregon border well into southern California. This destructive pest entered the state from the north in 1953, and in nine years has migrated to all the pear-growing areas as far south as San Luis Obispo.

Here you will learn what the "jumping plant louse" is; how it multiplies and spreads; what natural enemies and other factors help to control it; and, most importantly, what *you* can do to hold it in check.

A recent report states that the psylla produces a toxin which may be a major cause of "pear decline." It is hoped that this discovery will shed new light upon the former concepts of the insect's damage to the crop.

Because new chemicals and other means of controlling pests are being studied continuously, pear growers are urged to consult Leaflet 71, *Pest and Disease Control Program for Pears*, revised every year and available at the local offices of your University of California Farm Advisor.

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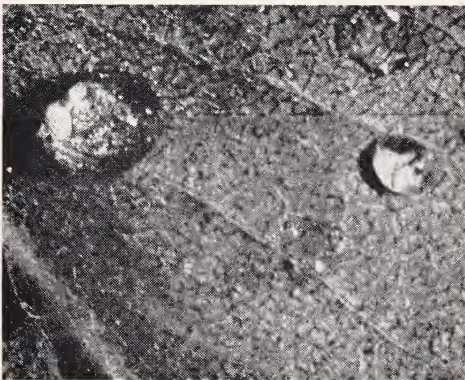
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What the pear psylla is • how
it reached us • its life history
and habits • nature of injury

THE PEAR PSYLLA has long been an important pest of pears wherever this commodity is grown. In Europe, there are several species which attack the pear, but so far as is known, *Psylla pyricola* Förster is the only species which has been recorded in the United States.

These insects are sometimes known as “jumping plant lice”—an appropriate term, for they are quite closely related to aphids, as well as to leafhoppers, whiteflies, scale insects, and cicadas. These all belong to the suborder Homoptera, many of whose members are of great economic importance. They have sucking mouthparts and live on the juices of plants.

How it arrived. In the eastern United States and eastern Canada, the pear psylla has been associated with pear culture since its introduction in 1832. In the West, the first infestation was found in the Spokane Valley of Washington in 1939. Attempts were made to eradicate the insect, but these efforts were unsuccessful and the project was abandoned. The pest continued to spread from the original introduction site throughout the pear-growing areas of Washington, as well as northward to British Columbia and southward to Oregon and California.



Honeydew droplets produced by pear psylla.

The first infestation in California was found in Del Norte and Siskiyou counties in June of 1953. The psyllids were limited to backyard pear trees, and their first occurrence in a commercial pear orchard was reported from Potter Valley, Mendocino County, in 1955. Since that time, the pest has moved to all the northern California pear-growing areas and as far south as San Luis Obispo.

All commercial pear varieties are attacked by the pear psylla. Quince is the only other host reported, but no infestations have been noted on quince in California, even in cases where it has been interplanted in heavily infested pear orchards.

Life stages

The pear psylla passes through three distinct stages in its development: egg, nymph, and adult.

The eggs are oval in shape, tapering to a point at the anterior (head or front) end. When first deposited they are white, but soon turn yellow. Before hatching, two red spots appear; these are the eyes of the developing nymph.

The nymph passes through five instars or stages, which require four molts before the final nymphal form is attained. The first-instar nymph is small, flattened, and yellow in color, with red eyes. The newly hatched psyllid will often wander over the leaf before it settles and produces honeydew, which surrounds the nymph in the form of a drop. The next three instars live immersed in such a droplet of honeydew. (See illustration at the left.)

The second- and third-instar nymphs are likewise flattened and yellow, with red eyes; therefore, the first three nymphal stages are most readily separated by



Adult pear psylla.

size differences. The fourth-instar nymph is not only larger, but also differs markedly in appearance. This stage possesses rudimentary wing pads, and varies in color from very light blue to dark green, with mottled areas of brown, yellow, and red. The fifth instar is commonly called the "hardshell" stage. A fully colored fifth-instar nymph varies from light to dark brown, with green areas on the abdomen. The wing pads are prominent, and this stage usually does not live within a droplet of honeydew. The nymphs generally cluster at the leaf petiole, but may also wander about the leaf surface (see front cover).

The adults are light in color upon emergence, but soon darken. The color then varies from reddish to dark brown. They are about one-eighth of an inch long. The wings are transparent, and are held rooflike over the body; there is a strong resemblance to a tiny cicada, as the accompanying picture shows. These mature insects are very active, and fly rapidly within and between trees. They are difficult to see in the field, as they characteristically fly or move to the opposite side of a twig when they are disturbed.

There are two adult forms of the pear psylla, a summer phase and an overwintering one. The latter is reported to be larger and darker in color than the summer form.

Seasonal life history

The pear psylla overwinters as an adult within the pear orchard. In other areas, the adults are reported to hide beneath bark or in trash on the ground. However, the behavior of overwintering adults under California conditions does not appear to follow this pattern. Studies carried on during the winters of 1960 and 1961 in Santa Clara County failed to reveal any psyllids in such locations. The few that were present were observed resting on twigs or branches in the trees. They are difficult to see, and usually remain quiescent unless they are touched. On warm days they may fly about, since occasional individuals were taken on sticky board traps in the orchard.

The overwintered adults become active in early spring, and egg laying usually begins in early February. In Santa Clara County, the first eggs were found on February 9 in 1960 and on February 14 in 1961.

Temperature. This seems to be the primary factor which influences the start of spring egg production. It has been generally stated that egg laying begins when temperatures rise above 50° F. In California, this is usually true, but the cumulative number of hours above 50°, and possibly above 60°, appears to be involved. Readings of 50° are frequently noted during the dormant season in California. In Santa Clara County in 1961, temperatures exceeded 50° on twenty-seven days between January 3 and January 31. During this period, readings above 60° were noted on fourteen days. In addition to temperature, initiation of egg laying appears to be influenced by the same conditions that govern tree development. As an instance, egg laying preceded bud break by only one week in 1961, even though temperatures had been favorable for six weeks.

The spring eggs are deposited on the fruit spurs, usually in the roughened bark at the base of the spur. (See picture.)

They are also found on the leaf buds and twigs. The females may deposit several eggs at one site and then fly to another spot to lay still more. In this manner, a small number of insects can spread an infestation over a considerable area. A single female has been reported to lay as many as five hundred eggs.

The overwintered adults live for a considerable time, and egg laying continues from the delayed dormant stage of tree development through the blooming period. When the buds open, the area of egg deposition shifts to the newly unfolding leaves.

The duration of the egg stage during the early spring is about twenty-one days when daily mean temperatures average 55° F.

The nymphs which hatch from eggs deposited early in the season enter opening buds and feed at the base of the leaves and flower parts. As the foliage develops, they move to the leaves, where they become established in their droplets of honeydew. There are several generations during the growing season, the number depending upon weather conditions. The first generation during the early spring may require up to sixty days to complete the cycle from freshly laid egg to adult.

The pear psylla is favored by moderate temperatures, as development is slowed by both cool and hot weather. Present indications suggest that field temperatures above 90° F. will bring about a decrease in egg deposition in the coastal areas of California. Temperatures above 100° in these regions restrict egg laying even further and cause heavy mortality among the young nymphs.

Foliage-season eggs. In late spring, summer, and fall, eggs are deposited on the leaves. The majority are laid upon the upper surface of the leaf, the others occurring on the underside and occasionally on the leaf edge. Most eggs are deposited in a line along the midvein of the leaf. Occasionally, a cluster will be found



Pear psylla eggs on fruit spur.

on the leaf blade. Usually, from 1 to 20 eggs will be found on a single leaf; however, in the late summer, leaves will often be found with 40 or more, and one count of 168 eggs on a leaf has been recorded. They are glued to the leaf surface by the female psyllid and cannot be dislodged by either wind or rain.

The nymphs which hatch at this season occupy both surfaces of the leaves, but are found most often on the underside of the leaf. Mortality between the egg stage and the first-instar nymphs averages about 80 per cent. The majority of young nymphs that survive from the egg move to the lower leaf surface before settling down in their honeydew droplets.

When infestations are heavy, the nymphs may be present in all parts of the trees. When low populations occur, they are more commonly found on the new growth, and frequently infest the tops of the trees and the sucker growth.

In contrast to aphids, mealybugs, and spider mites, the pear psylla develops readily on abandoned trees. Even though these trees may have poor growth and sparse foliage, the insects can exist and increase in numbers. For this reason, abandoned orchards and backyard trees are important sources of pear psylla and provide a reservoir for the dispersal of the pest.

In the fall, overwintering forms are found with increasing frequency, and an outward dispersal takes place. In many cases, an extremely heavy population will almost disappear within a short time. It seems evident that in California, most of the dispersal over considerable distances takes place during this season. The insects are strong fliers and can travel several miles. They are also carried by wind and other air currents; specimens have been taken in air samples from great heights. For these reasons, the pear psylla may appear in areas where none were formerly encountered.

In the spring, on the other hand, the psyllids' movements are generally confined to the area within an orchard.

Kinds of injury

A recent report from Washington State University, which implicates this pest as the producer of a toxin that may be one of the major factors in "pear decline,"

changes the former concept of pear psylla damage. In the past, the honeydew produced by the nymphs and the so-called "psylla shock" due to the insect's attack were believed to cause the principal damage to pears. These effects are directly related to the numbers of psyllids, but when true pear decline is considered, there are no data at hand to indicate what constitutes an economic level of infestation. Until information is obtained on the relationship of the pear psylla to true pear decline in the field, it must be assumed that the only logical approach is to reduce infestation to the lowest level that is economically possible.

Regarding the other aspects of damage by the pear psylla, the feeding of the nymphs can cause a yellowing of foliage which may result in premature defoliation. Necrotic spots (areas of dead tissue) may also appear on the leaves as a result of the attack, as the picture on this page indicates.



Pear twig showing necrotic areas on leaves resulting from pear psylla feeding.



Honeydew and sooty mold on pear leaves attacked by pear psylla.

This is primarily a local effect, restricted to the leaves which are directly attacked. The severity of such damage increases as the population builds up in an orchard. The honeydew produced by the nymphs is also a major factor because it drips onto the fruit. The black (sooty-mold) fungus which grows in the honeydew causes both fruit and foliage to assume a sooty appearance. (See picture.) Fruit thus disfigured is not suitable for fresh shipment.

Psylla shock is a phenomenon associated with heavy infestation. An orchard thus affected shows yellow foliage, retarded growth, and fruit of poor size and quality. The trees usually recover from these symptoms once the psylla is ade-

quately controlled. It has been reported, however, that trees have developed pear decline under such circumstances, depending upon a number of factors such as rootstock susceptibility and stress from a variety of causes.

Another aspect of pear psylla attack which has often been overlooked is the damage to developing blossoms by early-season infestations. It has been noted in California and reported in other areas that when the nymphs feed upon the opening fruit spurs, they may cause the developing fruit, flower parts, and leaves to shrivel and turn black. This may result in a reduced fruit crop when high psylla populations are present early in the season.

Natural controls

Several naturally occurring conditions offer possible restrictions against pear psylla populations. Among these may be mentioned insects (both parasites and predators), birds, and a lethal solidification of the psylla's own honeydew droplet. Studies during 1961 failed to reveal any noticeable effects produced by the above factors on psyllid populations, although honeydew crystallization had been noted in past seasons.

The hymenopterous (wasplike) parasite, *Psylledantus insidiosus* Crawford, has been recorded as attacking the pear psylla in the United States. Neither this species nor representatives of the several other known parasites have been recovered from populations in the western states.

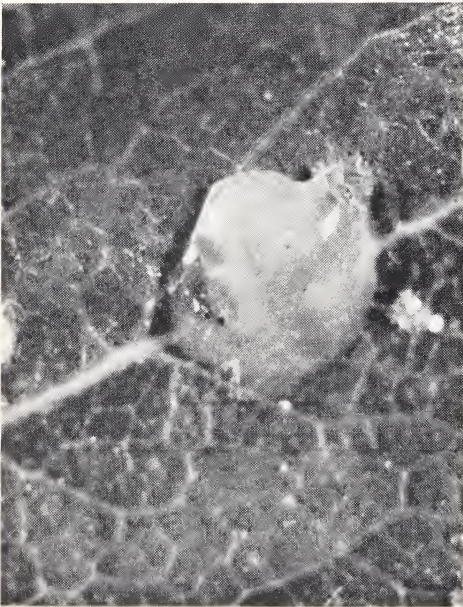
The larvae of various lacewings and lady beetles have also been reported as predators. An anthocorid bug, *Anthocoris*

melanocenus Reuter, has been reported to attack the pest in British Columbia. Both the green lacewing, *Chrysopa plorabunda* Fitch, and an anthocorid bug have been observed feeding upon it in California.

Green lacewing larvae feed upon all stages of the pear psylla, but appear to be bothered by the presence of honeydew droplets. However, none of these predators have significantly reduced the numbers of pests, even when both psyllids and predators were present in high populations. Lady beetles have been observed feeding upon other pests which were present along with the pear psylla, but in California, their larvae have not been seen attacking psyllid nymphs or eggs. Many species of birds were present in test orchards, but none were observed to be actually seeking psyllids in any stage of development.

Honeydew crystallization is a phenomenon reported from British Columbia, Washington, and the Sierra foothills of California. (See illustration.) These reports have suggested that the crystallization reaction is produced by the sudden onset of high temperature and low humidity. On three occasions during 1961, these conditions were experienced *without* the development of honeydew crystallization. On the first occasion in June, temperatures reached 111° F. and remained above 100° for six hours on two consecutive days. During the second observation, temperatures exceeded 100° on three consecutive days, with a high of 106°. The third hot spell also covered three days, with temperatures exceeding 100°.

A laboratory study was also made where psyllids in honeydew droplets were subjected to temperatures up to 113°. This level of heat killed the pear psylla in all stages, but failed to bring about crys-



Crystallized drop of honeydew on a pear leaf.

tallization of the honeydew. Where this reaction does occur, it seems reasonably certain that it is not because of a simple temperature-humidity relationship. Hot spells, however, appear to be of importance in influencing a population of psyllids.

Temperature vs. population. It has already been stated that the pear psylla is favored by moderate temperatures. Observations during the spring have shown a slow but steady increase in the psyllid population as temperatures increased from means of 55° F. to means ranging from 59° to 62°. The sudden onset of high temperatures at this point brought about a heavy reduction in the young nymphs and a sharp decrease in egg deposition.

As mean temperatures increased, the psyllid numbers increased in a like manner. The highest rate of egg production occurred during late August and early September. Mean temperatures averaged about 70° F. during this period, and daily high temperatures ranged from 75° to 86°. It should be noted that during the 1961 season, the greatest population level was reached after the completion of harvest and during a period when materials for control are not usually applied in California pear orchards.

In late September, immediately following the period of greatest activity, a dispersal occurred which reduced psyllid population levels to a very low point.

By early November, egg deposition had ceased completely, and only the overwintering adults remained. Mean temperatures at this time averaged about 59° F., a temperature which is above those reported to cause inactivity.

Artificial control

As just pointed out under "Natural Controls," currently known biological controls cannot be relied upon to control the pear psylla adequately. Weather factors can influence populations, and under some circumstances may drastically re-

duce an infestation. Unfortunately, since the conditions necessary for natural control cannot be predicted with any degree of accuracy, it is necessary to rely upon artificial measures. At present, an effective spray program can keep the pests at low levels during the season.

Resistance to insecticides is recognized to be a serious problem in controlling psyllid infestations in the Pacific Northwest. There is a strong possibility that the same situation will soon arise in California. Already, there are indications that certain chemicals no longer provide the degree of control obtained in preceding seasons. For this reason, it is difficult to present a spray program that will be useful for more than a single season. With this in mind, the discussion on control will be limited to proper timing of applications and a few generalities with respect to insecticides.

Pre-bloom, foliage, and post-harvest are the three periods during which insecticides may be applied. Heretofore, most of the effort in psyllid control has been directed toward application of chemicals during the foliage period. Infestations preceding the petal-fall stage and after harvest have been neglected unless heavy psyllid numbers were encountered. With increased emphasis on complete seasonal control, these two periods cannot be ignored.

A treatment at the pre-bloom period can accomplish two purposes. It destroys the adults which are contacted by the spray, and provides a residue that is toxic to newly hatched nymphs. The chemicals which have been most useful are a combination of dormant oil plus one of the organic phosphate insecticides. Oil will kill adult psyllids; oils of higher viscosity seem to be more effective. In addition, the pear psylla will not deposit eggs upon an oily surface. When an organic phosphate is combined with the oil, the kill of adults is enhanced, and a toxic residue is provided. Oil in combination with lime-sulfur has been suggested in other

areas, but experience in California indicates that this combination is not so effective as the oil-organic phosphate treatment. The timing of the pre-bloom spray is important, and the delayed dormant period in February is preferred.

If sprays are applied before the adults are active, those in the trees may be destroyed, but reinfestation may occur from neighboring orchards. Egg deposition is well under way by mid-February, and a spray at this time will provide the most effective control. If the pre-bloom spray is delayed until the open-cluster bud period, good control will result, but there is a danger of oil injury to the trees at this time. If circumstances are such that treatment must be delayed until the period just before bloom, a residual compound such as dieldrin may be used to avoid possible injury from an oil-organic phosphate combination. The danger of damage to pollinating insects from a spray applied close to the bloom may be important, and this is another reason for giving preference to the delayed dormant spray.

During the foliage season (from the first cover spray until harvest), there are a number of compounds that are useful for control. One of the several commercially available organic phosphates or a compound such as dieldrin will provide control. The program against psylla will depend upon the over-all codling moth schedule of sprays. If DDT is used, it will be necessary to add a compound that is effective against the psylla. If Guthion or Sevin is used in the codling moth sprays, it may not be necessary to add additional compounds.

The number of applications necessary for optimum control will depend upon local conditions. At present, there is no feasible method of artificial trapping that can be used to determine the necessity for treatments. Sticky boards hung in the tree will indicate the presence of pear psylla when high populations are present, but are of doubtful value for in-

festations of low intensity. The individual grower should check his orchard carefully to avoid excessive build-up between treatments. It should be kept in mind that the psyllids prefer the new growth; therefore the sucker growth in the centers of the trees and the new growth at their tops should be carefully examined.

Spray thoroughly. Regardless of the choice of insecticides, the importance of complete spray coverage should be emphasized. It is not necessary to apply excess water in order to assure coverage, but the centers and tops of the trees should be checked to be sure a sufficient deposit is present. An effective insecticide will be worthless unless careful attention is given to its proper application.

It is common to have a substantial infestation develop during the harvest and post-harvest periods on pears because temperatures are milder, which permits a more rapid increase of psyllid numbers. Since direct damage to fruit or foliage is less noticeable under these conditions, there has been little inclination in the past to apply post-harvest sprays specifically for the control of pear psylla. As is the case during the pre-bloom period, a post-harvest spray should be considered in view of the increased emphasis on a seasonal control program. There are several materials and combinations that can be used for a fall cleanup spray. If psylla alone is involved, a residual-type material such as dieldrin may be used. Dilan has recently been tested, with outstanding results. The material provides a rapid knockdown with a long residual action. Since there is no established tolerance for Dilan, its use must be restricted to the post-harvest period for the present.

When mites are present. Neither of the above compounds will offer control of other pests which may be present during the post-harvest period. As a general cleanup treatment against pear psylla and spider mites, an oil-organic phosphate combination will be most effective. The pear spray program suggests the use of

either Phostex or Diazinon plus oil for blister mite control in the post-harvest period. The latter combination should control pear psylla, and Phostex will also be effective if combined with oil. Lime-sulfur and oil may be partially effective, but should not be relied upon to reduce a heavy psyllid population.

It has been observed that an oil-organic phosphate combination as a post-harvest spray will often cause some defoliation. The leaves affected are primarily those suffering from either psyllid or spider mite damage, and it is doubtful if this defoliation is of primary importance. It would seem more important to

control the insects or mites than to be concerned with the loss of a few leaves.

It is obvious that the choice of a program for post-harvest will depend upon the individual pest problems in a given orchard. There is no single panacea for all the problems, and the individual grower must choose the program that best fits his situation.

The above discussion on chemical control may seem complicated because of the variety of materials available for use. However, it does provide flexibility, so that the program can be tailored to the variety of pest problems in the various pear-growing areas of California.

In order that the information in our publications may be more intelligible, it is sometimes necessary to use trade names of products or equipment rather than complicated descriptive or chemical identifications. In so doing, it is unavoidable in some cases that similar products which are on the market under other trade names may not be cited. No endorsement of named products is intended, nor is criticism implied of similar products which are not mentioned.

TOO MANY INSECTS . . . NOT ENOUGH INSECT-FIGHTERS



Students and instructor watch spray demonstration on Oxford Tract, Berkeley

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